



CALCULATIONS OF EARTHWORK QUANTITY BY USING CIVIL 3D

Asmaa Abdul Al- Jabbar Hadi ¹, Montaqa Mokhalad Alhaydary ²

- 1) Lecturer, Civil Engineering Department, Mustansiriyah University, Baghdad, Iraq.
- 2) Assist Lecturer, Civil Engineering Department, Mustansiriyah University, Baghdad, Iraq

Abstract: This study aims to calculate the earthwork volumes by Civil 3D. Civil 3D is modern software techniques application used by civil engineers and other professionals to plan, design, and manage engineering projects. These projects need an efficient techniques for computation the earthworks volumes with high accuracy and short time in both theoretical and practical works. Surveying methods for the earthworks quantity are most common and important activities for civil engineers these modern techniques have a potential to offer more productivity and efficiency for Civil 3D in earthwork quantity calculation. Civil 3D connects design and documentation to enabling you to boost productivity, deliver higher quality designs and construction documenters.

Keywords: *earthwork; Volume; Contour Map; Civil3D.*

حسابات الاعمال الترابية باستخدام برنامج

Civil 3D

الخلاصة: تهدف هذه الدراسة لحساب الاحجام الترابية باستخدام برنامج Civil 3D. برنامج Civil 3D هو تطبيق تقنيات البرمجيات الحديثة المستخدمة من قبل المهندسين المدنيين وغيرهم من المهنيين لتخطيط وتصميم وإدارة المشاريع الهندسية. هذه المشاريع تحتاج إلى تقنيات فعالة لحساب الاحجام الترابية بدقة عالية ووقت قصير في كل من الأعمال النظرية والعملية. طرق المسح لأعمال حساب الاحجام الترابية هي من الأنشطة الأكثر شيوعا واهمية للمهندسين المدنيين هذه التقنيات الحديثة لديها القدرة على تقديم المزيد من الإنتاجية والكفاءة باستخدام Civil 3D في حساب هذه الحجوم. يربط Civil 3D التصميم والوثائق مما يمكن الحصول على زيادة الإنتاجية وتقديم تصاميم عالية الجودة ومستندات البناء.

1. Introduction

The earthwork is one of the main components of large construction and infrastructure projects. Earth and excavation works are among the most common and important activities in civil engineering field. For these demands, accurate 3D shape reconstruction and volume computations, which have always been a challenge to be captured precisely, safely and

Rapidly, should be available to be used in many applications such as erosion studies, mining activity monitoring and terrain assessment for construction [1].

*Corresponding Author asmaa6hayani@gmail.com

The accuracy of computed volumes depends mainly on the correct modeling of the Earth surface, which is usually represented by certain number of specific 3D coordinate points with good distribution, and the used interpolation methods .[2]

Reliable and accurate earthwork volume calculation is one of the most important components in civil Engineering projects. Civil 3D software package, developed by Autodesk Corporation in this context, is a Building Information Modeling (BIM) solution for civil engineering that can be used in transportation, land development and water conservancy project, supporting 3D volume calculation based on DTM. This study chooses Civil 3D package as the tool to compute earthwork volume in 3D method. This paper verifies the feasibility of calculating the earthwork volume in 3D method by Civil 3D software by using contour map.

2. Literature Review

The earthwork volume is one of the most important objectives in horizontal and vertical alignment optimization, so most researches firstly focused on the cut-fill balancing to minimize the cost. Stark and Nicholls (1972) started to employ linear programming into earthwork optimization and this method was developed by Mayer and Stark (1981) and Nandgaonkar (1981). Easa (1988) [3] integrated the selection of roadway grades and the minimizing of earthwork into one problem by enumerating all technically feasible grades and solving the linear programming problem. But Easa's method couldn't guarantee the global optimality, so Moreb (1996) [4] proposed a model that succeeded not only in reducing the time problem Goktepe and Lav (2003) [5] then developed a method called weighted ground elevation that considered the material properties in grade line selection to balance the cut and fill volume. All this researches were conducted by average-end-method.

Bao (2011) [6] applied DTM on the earthwork calculation of land consolidation where the MapGIS DTM analysis function was utilized to transform the elevation points into Triangulated Irregular Network (TIN) and fixed the layout elevation by iterative calculation aimed at the balance between cut and fill. This application of 3D method could also be used in roadway design and volume calculation.

The latest report of roadway earthwork volume calculation by 3D method was conducted by Kerry, Dianne and James [7] (2012). The researchers employed three-dimensional laser scanning to create a surface of the original terrain based on the finite element method.

As reviewed above, 2D methods such as average-end-method, and other models improved based on them, are not accurate in theory but practically used in engineering. The real and accurate volume could be got by DTM method, especially with the help of updated CAD software; however, 3D method is currently only applied in the area of landslide volume computation and land consolidation. The objective of next phase is to bring 3D method based on DTM into earthwork calculation.

3. Using the Software Product AutoCAD Civil 3D

AutoCAD Civil 3D can be used for graphical representation of the plan and to create digital elevation model of the terrain. The facilities of the program are extremely high and

it offers virtually unlimited possibilities. This software solution creates models that facilitate script analyzes; both in the preliminary stages of the project and the improvement of the performance and the cost appraisal of the project, both during construction phase and in the running phase .

The steps to achieving a digital model using AutoCAD Civil 3D are:

- Opening a new project;
- Import points;
- Drawing in 3D polyclinics the boundaries of the studied area and the break lines;
- Making digital model

Once the digital terrain model has been made, the following step is the construction of the infrastructure 3D model. The construction of a 3D model is a very laborious process and requires several steps, depending on the particularities of each project. During the process, specific issues can be differentiated that can be resolved on the basis of measurements and processing in the CAD environment, such as topographic problems, 2D and 3D analysis and design problems of communication. On construction projects it is often necessary to modify the existing ground levels to create platforms to build on. Accurately calculating the volumes of soil that must be removed (cut) or added (fill) to create the final ground levels is an essential part of the planning process. In this article we are going to describe how these volumes can be calculated.

4. Topography

Since the functions for the exploitation of the topographic data are fully integrated in AutoCAD Civil 3D , you can have an integrated working environment for all tasks required for direct import of raw survey data , reducing errors by using the method of least squares, editing of survey observations , automated creation of planimetric detail and relief etc. and what is most important , the results - points planimetric details and surfaces - can be used throughout the design process.

Calculating the volume of the embankment. The average projected surface method represents a software solution that allows the evaluation of the quantities of earth occupied by the buildings in a shorter time. The specific design tools for the infrastructure provide a more efficient design of roads and highways. You can build interactive models of intersections of roads, which is updated dynamically. The CAD software presents drawing standards to control many aspects of the form and content of drawing, colors, linetypes, contour increments, labeling and many other functions that are fully controlled by styles.

AutoCAD Civil 3D includes geospatial analysis functions and digital cartographic production necessary for the engineering work processes . It is possible to analyze spatial relationships between drawing objects .It can also retrieve or create new information by super impositionning two or more topologies . The generation and use of a buffer zone created at a certain distance from the other entity is performed in order to select the entities containing therein. Also , you can create detailed maps using geospatial information publicly available . as shown in figure (1).

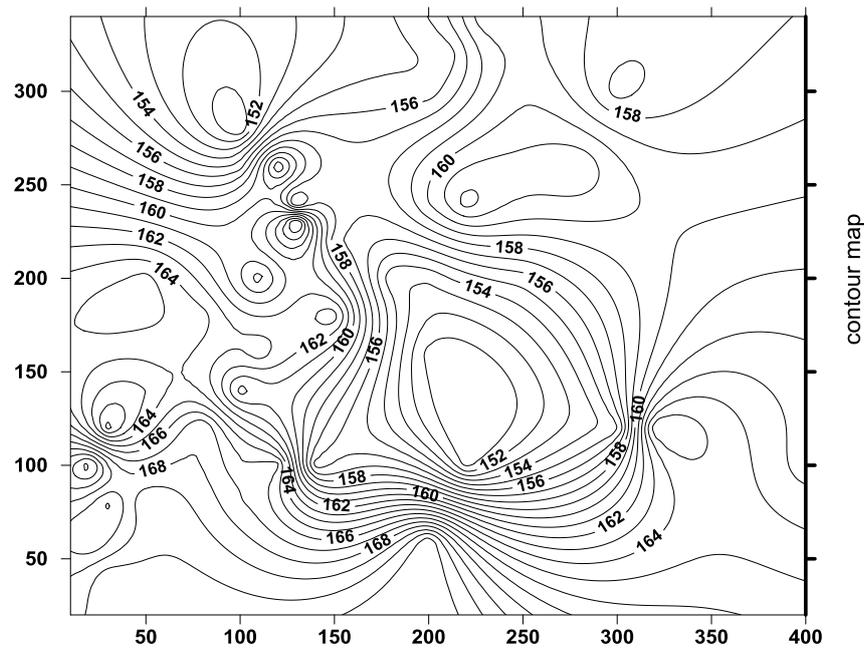


Figure (1) contour map

5. Software

Modern computer software allows earthworks volumes to be calculated quicker and more accurately than either of the two manual methods described above. There are a number of software products available for this purpose. These products vary greatly in terms of complexity and price. The first stage of producing an estimate using software is to import the existing terrain. Once this is done the proposed terrain is drawn, and the software automatically calculates the cut and fill volumes required.

Different software products use different methods to generate the estimate. Some will essentially apply the grid method described above on a fine-resolution grid, whereas others use a triangulation of the terrain to calculate volumes directly. In any case, the processing power of modern computers means that a high level of accuracy can be achieved in a fraction of the time it would take to produce a manual estimate. There are many advantages to using software to calculate earthworks volumes, and most companies which estimate earthworks on a regular basis will use software to do so.

Perhaps the principal advantage of software is that it is much quicker to produce a more accurate estimate when compared with the manual methods described above. Another major advantage is that most modern software products of this type will have useful display options which can be exported for presentations.

Shading cut and fill depths across the project is a particularly useful facility. Rightly or wrongly, people tend to be more impressed by computer-generated images than they are by hand calculations, and trust them more. This is particularly important when presenting your estimates to a client as part of a tender.

6. Calculation of Earthwork Estimating

The basic process of determining earthwork quantity estimates is the same for the design consultant and the earthwork contractor by:

- 1-Creating digital 3D model of the existing surface, accounting for stripping of topsoil
- 2-Calculate the volume difference between the existing and proposed surfaces.
- 3-Generate reports or cut-and-fill maps .

Today, many different software packages are available for creating existing and proposed (digital models) and calculating the volume difference between them. Most programs also provide tools for generating earthwork quantity volume reports. The programs features and capabilities can vary widely based on price and the intended purpose of the software (i.e., a civil engineering design suite versus a dedicated earthwork quantity program). Generally, earthwork software Civil 3D, provide a comprehensive design solution for engineers and surveyors for all aspects of a project including tools for earthwork volume quantity takeoff estimates. The first step in estimating the earthwork volumes is for the surveyor or design consultant to create a digital model of the existing ground. Typically, engineer and surveying consultants create the existing ground using field-observed survey data. Surveyor's field data(coordinates) are usually contained in a data collector file which can be downloaded to create a modal as shown in figure (2).

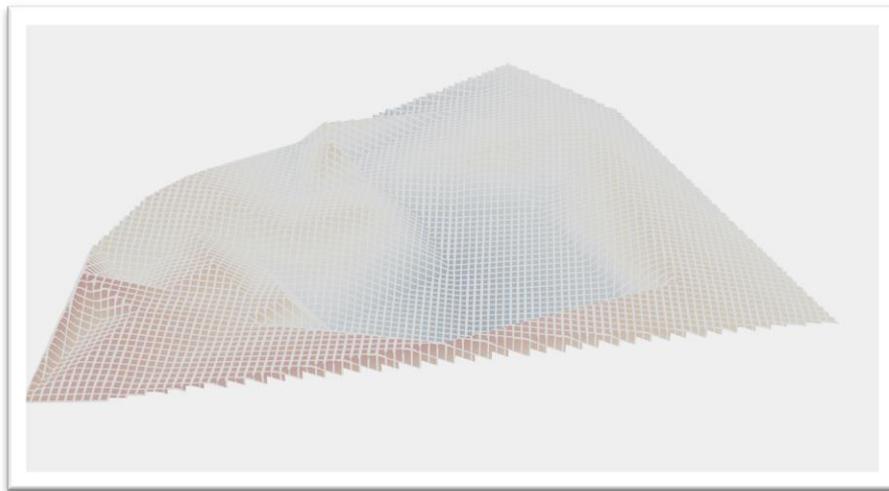


Figure (2) Digital Terrain Model (DTM).

If field data is not available, the consultant may elect to form the existing ground surface by using other sources such as digitized contours from paper plans, 3D vector entities from raster (scanned) contour maps or 3D models created from 2D CAD files. The earthwork contractor must also create a model of the existing ground. But, he works from a combination of CAD files and paper plans provided to him. The earthwork contractor's software toolbox includes features dedicated to handling this task. The most common method of turning paper plans into a 3D surface model is by digitizing .Surface models can also be created by converting two dimensional drawing entities such as contour lines in CAD files into 3D data. Most applications support CAD File import and offer some conversion tools to prepare the data for use in creation modal.

The process of creation of a 3D model and of determining its (distance, area, volume) it presents a means to its resolving. The terrain model presents the basic element of all projects and is used at creating longitudinal profiles, calculating volumes of the project for all areas with different elevation as shown in Figure (3).

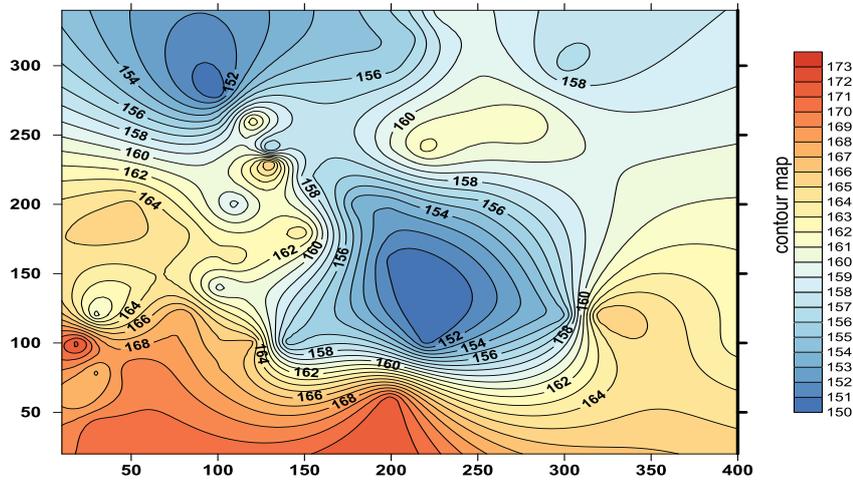


Figure (3) Contour Map.

Level Surface defined by $Z = 148\text{m}$

Cut & Fill Volumes

Positive Volume [Cut]: $1506109.5875114\text{m}^3$

Negative Volume [Fill]: 0

Level Surface defined by $Z = 155\text{m}$

Cut & Fill Volumes

Positive Volume [Cut]: $717886.30631651\text{m}^3$

Negative Volume [Fill]: 85376.7188050m^3

Level Surface defined by $Z = 173\text{m}$

Cut & Fill Volumes

Positive Volume [Cut]: 0

Negative Volume [Fill]: $1613890.4124885\text{m}^3$

If determine part of area with the coordinates shown in Table (1) and map of the part shown in figure (4). Calculate the volume with chosen elevation as shown in figure (5).

Table (1) Coordinates of determine area.

X	Y
191.95017	136.61845
202.57255	158.5271
190.62238	185.74694
146.80507	183.75525
106.30726	166.49388
107.63506	134.62675
132.1993	137.94624
148.79677	145.91303
167.38593	152.55201
176.01661	147.90472
191.28628	136.61845

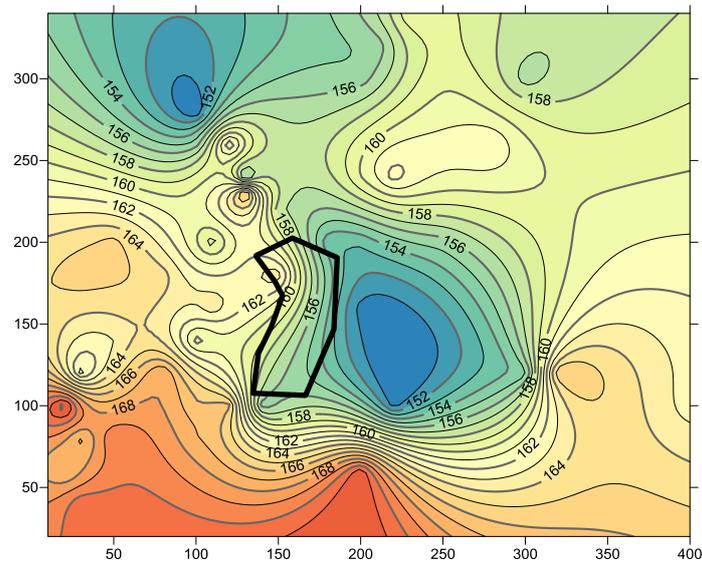
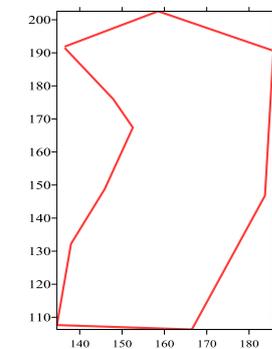


Figure (4) Map with determine area



Level Surface defined by Z = 156m

Cut & Fill Volumes

Positive Volume [Cut]:	5130.9591024735m
Negative Volume [Fill]:	1483.8796119073m

Figure (5) Calculation of volumes.

7. Conclusions

The work presented in this paper provides a quantified model of earthwork with the civil 3d techniques to assist general practices in earthwork, including preliminary planning and measuring cut and fills volumes. Earthwork modal were used civil 3D to he calculate excavation construction sites. The advantages of this model earthwork are:

- 1-T data from the planning can be reused for earthwork
- 2-The civil 3D method guaranties an accurate calculation and positioning of earth Masses to be excavated or to be filled.
- 3-Can be directly use the source data to provided optimize the project schedule and support the earthwork planning process.
- 4-Modeling with civil 3D helps expedite the design process and minimizes problematic issues. The process of 3D-modelling takes a central part in a project design nowadays. A lot of projects require that 3D models should be delivered as a final result in the project. 3D models are widely used in a project design. They can be used for the calculations, the drawings production and for the data control

in coordination models

8. References

1. Yilmaz, H. M. (2010) "*Close Range Photogrammetry in Volume Computing*". Society for Experimental Mechanics
2. Yakar, M.; H. M. Yilmaz and O. Mutluoglu (2010). "*Close Range Photogrammetry and Robotic Total station in Volume Calculation*". International Journal of the Physical Sciences, Vol. 5 (2), pp. 086-096.
3. Easa, S (1988) "*Selection of Roadway Grades that Minimize Earthwork Cost Using Linear Programming*" Transportation Research, 22(2), 121-136.
4. Moreb, A.A. (1996) "*Linear Programming Model for Finding Optimal Roadway Grades that Minimize Earthwork Cost*". European Journal of Operational Research, 93, 148-154.
5. Goktepe, A.B., & Lav, A.H. (2003) "*Method for Balancing Cut-Fill and Minimizing the Amount of Earthwork in the Geometric Design of Highway*". Journal of Transportation Engineering, 129(5), 564-571
6. Bao, Y. (2011) "*Applications of the MapGIS-based Digital Topographic Model on Earthwork Calculation on Land Consolidation*". Proceeding of International Conference on Computer Distributed Control and Intelligent Environmental Monitoring, China.
7. Kerry, T.S., Dianne, K.S., & James, P.P. (2012) "*Road Construction Earthwork Volume Calculation Using Three-Dimensional Laser Scanning*". Journal of Surveying Engineering, 138(2), 96-99.